CHEMICAL ENGINEERING

VOLUME TWO

UNIT OPERATIONS

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liquid, the separation from toluene is relatively easy. A flowsheet for accomplishing this is shown in Fig. 11.44*b*, where the binary mixture is introduced more or less centrally into the extractive distillation tower (1), and phenol as the solvent is introduced near the top so as to be present in high concentration upon most of the trays in the tower. Under these conditions iso-octane is readily distilled as an overhead product, while toluene and phenol are removed as a residue. Although phenol is relatively high-boiling, its vapour pressure is nevertheless sufficient for some to appear in the overhead product. The solvent-recovery section of the tower, which may be relatively short, serves to separate the phenol from the iso-octane. The residue from the tower must be rectified in the auxiliary tower (2) to separate toluene from the phenol which is recycled, but this is a relatively easy separation. In practice, the paraffin hydrocarbon is a mixture rather than pure iso-octane, but the principle of the operation remains the same.

The solvent to be used will be selected on the basis of selectivity, volatility, ease of separation from the top and bottom products, and the cost. The selectivity is most easily assessed by determining the effect on the relative volatility of the two key components of addition of the solvent. The more volatile the solvent, the greater the percentage of solvent in the vapour, and the poorer the separation for a given heat consumption in the boiler. It is important to note that the solvent must not form an azeotrope with any of the components. Some of the problems of selecting the solvent are discussed by Scheibel[26] who points out that use may be made of the fact that, when two compounds show deviations from Raoult's Law, then one of these compounds shows the same type of deviation with any member of the homologous series of the other component. Thus the azeotropic mixture acetone (b.p. 329·6 K)–methanol (b.p. 337·9 K) has 20 mol per cent acetone and boils at 328·9 K, i.e. less than the boiling point of either component. Then any member of the series ethanol (357·5), propanol (370·4), water (373·2), butanol (391·0) may be used as an extractive agent, or in the series of ketones, methyl *n*-propyl ketone (375), methyl *iso*-butyl ketone (389·2). The advantage of using a solvent from the alcohol series is that the more volatile acetone will be taken overhead, though water would have the advantage of cheapness. Pratt[27] has given details of a method of calculation for extractive distillation using the system acetonitrile–trichlorethylene–water as an example.

Extractive distillation is usually a more desirable process than azeotropic distillation since no large quantities of solvent must be vaporised. Furthermore, a greater choice of added component is possible since the process is not dependent upon the accident of azeotrope formation. It cannot be conveniently carried out in batch operations, however.

Azeotropic and extractive-distillation equipment can be designed using the general methods for multicomponent distillation, and detailed discussion is available elsewhere[1,20,28,29].

11.9. STEAM DISTILLATION

Where the material to be distilled has a high boiling point, and particularly where decomposition might occur if direct distillation were employed, the process of steam distillation can be used. Steam is passed directly into the liquid in the still; the solubility of the steam in the liquid must be very low. Steam distillation is perhaps the most common example of differential distillation.

Two cases are possible. The steam may be superheated and provide sufficient heat to

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